ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence Funding[1]

(Dollars in Millions)

	FY 2022 Actual[2]	FY 2023 Estimate Base	Disaster Relief Supplemental		FY 2023 Estimate Total	FY 2024 Request
			Base	CHIPS and Science		
BIO	$20.00	$20.00	-	-	$20.00	$20.00
CISE	346.96	344.00	-	-	344.00	389.00
EDU	59.61	35.00	-	-	35.00	42.50
ENG	88.00	88.00	-	-	88.00	97.00
GEO Programs	1.00	5.00	-	-	5.00	5.00
MPS	134.18	75.21	-	-	75.21	84.20
SBE	17.74	16.92	-	-	16.92	19.59
TIP	100.00	52.45	25.64	24.48	102.57	138.19
IA	14.30	1.00	-	-	1.00	1.00
Total	**$781.79**	**$637.58**	**$25.64**	**$24.48**	**$687.70**	**$796.48**

[1] Funding displayed may have overlap with other topics and programs.

[2] FY 2022 Actual may be greater than future fiscal years due to the receipt of more meritorious proposals than expected.

Overview

AI is advancing rapidly and is increasingly demonstrating its potential to significantly transform our lives. NSF has a long and rich history of supporting AI research, setting the stage for today's widespread use of AI technologies in a range of sectors, from commerce to healthcare to transportation. NSF-funded research is now laying the foundation for advances in AI that will transform not just these areas, but essentially every area of human endeavor, including science, education, energy, manufacturing, and agriculture. NSF's AI portfolio spans AI algorithms, robotics, human-AI interaction, and advanced cyberinfrastructure for AI, as well as use-inspired research in neuroscience, biology, chemistry, physics, intelligent transportation, and many other disciplines across the full breadth of science and engineering in which NSF invests.

NSF supports fundamental research, education and workforce development, and access to data and advanced computing research infrastructure that collectively enhance AI. NSF's ability to bring together numerous fields of scientific inquiry uniquely positions the agency to lead the Nation in expanding the frontiers of AI. In FY 2024, NSF will continue support for foundational research in AI, including machine learning (ML) and deep learning, natural language technologies, knowledge representation and reasoning, robotics, and computer vision, along with fairness, ethics, accountability, transparency, explainability, safety, security, and robustness across all areas of AI. In addition to foundational research in these areas, NSF also supports use-inspired and translational research that links AI innovation with science and the economy, including agriculture, manufacturing, biotechnology, and health. Equally important is NSF's investment in education and learning, which grows the human capital and institutional capacity needed to nurture the next generation of AI

researchers and practitioners as well as AI technology in support of learning more broadly. Finally, advances in AI rely upon access to data as well as NSF-funded advanced computing research infrastructure.

Through collaboration and coordination with the Office of Science and Technology Policy (OSTP), NSF leadership is helping to drive and coordinate AI R&D efforts across the federal government. For example, the NSF Director co-chairs the National Science and Technology Council's (NSTC) Select Committee on AI, which advises the White House on interagency AI R&D priorities and establishes structures to improve government planning and coordination. In addition, NSF co-chairs the NSTC Machine Learning and AI (MLAI), NSTC Networking and Information Technology R&D (NITRD), and NSTC Future Advanced Computing Ecosystem (FACE) Subcommittees, as well as the more AI-focused R&D Interagency Working Group, all of which serve to coordinate federal R&D investments in AI as well as other related information technology areas, including the underlying advanced computing ecosystem that is critical for advancing AI.

In June 2019, the NSTC Select Committee on AI issued an update to the *2016 National Artificial Intelligence Research & Development (AI R&D) Strategic Plan*[1]. NSF was a key contributor to the *National AI R&D Strategic Plan: 2019 Update*[2], which identified eight strategic priorities and provided a coordinated federal strategy for AI R&D to ensure that the United States continues to lead the world in cutting-edge advances in AI that grow our economy, increase our national security, and improve our quality of life. NSF is also a key contributor to an anticipated 2023 update to the AI R&D strategic plan, and, in general, NSF's activities in AI research, education, and research infrastructure are directly aligned with this strategic plan update.

A PCAST report on *Recommendations for Strengthening American Leadership in Industries of the Future* (June 2020) recommended that federal agencies partner with industry and academia to ensure the effective transition and translation of early-stage research outcomes into applications at scale. This report helped to inform the expansion of the NSF National AI Research Institutes program to include industry partners. A subsequent 2021 PCAST report, *Industries of the Future Institutes: A New Model for American Science and Technology Leadership* (January 2021) builds upon this strategy for convergent AI research, emphasizes the ubiquitous role of AI in societal challenges, and situates the National AI Research Institutes program as a long-term multi-sector initiative to enhance innovation through foundational and use-inspired research.

The National AI Initiative Act of 2020[3] called on NSF in coordination with OSTP to form a National AI Research Resource (NAIRR) Task Force to investigate the feasibility of establishing a NAIRR and develop a roadmap detailing how such a resource could be established and sustained. Comprising members from government, academia, and the private sector, the NAIRR Task Force submitted its final report to the President and Congress, *Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a NAIRR* in January 2023[4]. The report offers a roadmap and implementation plan for the NAIRR that would build on existing and future Federal investments.

[1] www.nitrd.gov/pubs/national_ai_rd_strategic_plan.pdf
[2] www.nitrd.gov/pubs/National-AI-RD-Strategy-2019.pdf
[3] www.congress.gov/116/crpt/hrpt617/CRPT-116hrpt617.pdf#page=1210
[4] www.ai.gov/wp-content/uploads/2023/01/NAIRR-TF-Final-Report-2023.pdf

Goals

NSF's leadership in AI has three intertwined components:

1. *Fundamental AI Research:* Sustain long-term investments in fundamental AI research that will give rise to transformational technologies and, in turn, breakthroughs across all areas of science and engineering and across all sectors of society.
2. *Education and Workforce Development:* Develop AI systems that enhance learning for all and grow the next generation of talent to advance the U.S. AI R&D workforce, including those working on AI systems and those working alongside them.
3. *Access to Data and Advanced Computing Research Infrastructure:* Provide access to advanced cyberinfrastructure including scalable computing resources as well as deep, high-quality, and accurate training datasets to advance AI research and education.

FY 2024 Investments

<u>Fundamental AI Research</u>

- In FY 2024, NSF will continue support for the National AI Research Institutes program that was initiated in FY 2019 to create national hubs for universities, federal and local agencies, industry, and nonprofits to advance AI research and workforce development in key areas addressing grand challenges. In FY 2020 and FY 2021 NSF funded 14 institutes in themes that included foundations of ML; trustworthy AI; AI-augmented learning; AI for accelerating molecular synthesis and manufacturing; human-AI interaction and collaboration; AI and advanced cyberinfrastructure and AI for discovery in physics. Each AI Institute receives up to $20.0 million over five years. NSF also partnered with the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA) to establish two additional institutes in each of FY 2020 and FY 2021, advancing AI-driven innovation in agriculture and food systems; these four AI Institutes are being fully supported by USDA NIFA. NSF issued the latest solicitation in Fall 2021 and anticipates making up to seven awards in FY 2023, bringing the total number of institutes funded to 25. This solicitation continues the ongoing collaboration with USDA NIFA and the Department of Homeland Security, Science and Technology Directorate (DHS S&T) as well as new partnerships with the Department of Defense Office of the Undersecretary of Defense for Research and Engineering (DOD OUSD(R&E)), National Institute of Standards and Technology (NIST), Department of Education Institute for Education Sciences (IES), and IBM Corporation. In FY 2024, NSF and its partners will begin evaluating the first institutes for possible renewal.
- NSF began a new initiative called Expanding AI Innovation through Capacity Building and Partnerships (ExpandAI). This effort is designed to support the continued growth of a broad and diverse interdisciplinary research community for the advancement of AI and AI-powered innovation. The ExpandAI program aims to significantly broaden participation in AI research, education, and workforce development through capacity development projects and through partnerships within the National AI Research Institutes ecosystem. ExpandAI also includes partnerships with other federal agencies (DHS, DOD, NIST, USDA NIFA, and DOD).
- In FY 2023, NSF began a targeted effort to enhance research in safety of AI systems that operate autonomously, in partnership with Open Philanthropy and Good Ventures. The Safe Learning-Enabled Systems program aims to create a community of researchers who collaborate on the topics of design and implementation of safe learning-enabled systems; methods for rigorously reasoning (including probabilistically/statistically/logically) about safety amid uncertainty (in data, environment observations, system calibration, etc.); and machine learning. The desired outcome

is that future safe learning-enabled systems will be constructed with sound design principles which practitioners can leverage to achieve safety specifications.

- In FY 2020, NSF, in collaboration with the Simons Foundation, funded two five-year collaborative projects on the Mathematical and Scientific Foundations of Deep Learning. Interdisciplinary teams of computer scientists, engineers, mathematicians, and statisticians will advance theoretical and foundational investigations into deep learning, with a view to laying the groundwork for a rigorous science of deep learning. In FY 2024, NSF will continue support for these centers. In addition, beginning in FY 2021 and continuing for three years, NSF is supporting more than a dozen smaller-scale projects seeking to advance the mathematical and scientific foundations of deep learning.
- In FY 2024, through the Foundational Research in Robotics (FRR) program, CISE and ENG will continue to support robotics research that combines advances in engineering with innovations in computer science. The FFR program invests in robotics and autonomous systems that exhibit significant levels of computational capability and physical complexity, including research related to the design, application, and use of robotics to augment human function, promote human-robot interaction, and increase robot autonomy, many of which depend critically on AI approaches.
- The NSF Convergence Accelerator program has emphasized AI through a variety of themes dating back to FY 2020. For example, in FY 2021, the program invested in a set of projects focused on AI-Driven Innovation via Data and Model Sharing. Similarly, in FY 2022, the program emphasized AI through themes on the development of innovative assistive or rehabilitative technologies to help improve equity, inclusion, and accessibility for persons with disabilities; informatics for sustainable materials; and modeling and prediction to address food and nutrition security.
- In FY 2023 and FY 2024, as an outgrowth of a Convergence Accelerator program track on Open Knowledge Networks (OKN), and following an OKN Innovation Sprint co-led by NSF and the White House Office of Science and Technology Policy, NSF together with multiple other federal agencies will invest in the development of a prototype OKN — an interconnected network of knowledge graphs supporting a very broad range of application domains. Open access to shared information, as afforded by the prototype OKN, is essential to the development and evolution of AI and AI-powered solutions needed to address complex challenges facing the Nation.

<u>Education and Workforce Development</u>

- As noted above, in FY 2020, NSF established a five-year National AI Research Institute for AI-augmented learning to radically improve human learning and education writ large in formal (e.g., preK-12, undergraduate, graduate, vocational education) and informal settings. In FY 2021, NSF established two additional five-year National AI Research Institutes in AI and Education. The primary focus of these institutes is to support AI-driven innovation to improve human learning and education. One AI Institute is pursuing research to support highly adaptable, personalized, and distributed AI systems to expand STEM learning across diverse learners and settings in the context of preK-12 education. The other Institute is advancing AI-driven research and innovations for learners with or at risk for disabilities. Both AI Institutes are addressing achievement and opportunity gaps, particularly for learners from disadvantaged or underserved communities and pursue outcomes with direct educational impact.
- In partnership with the Department of Education's Institute of Education Sciences, NSF established a five-year AI Institute for Exceptional Education that will focus on the speech language pathology needs of children. This AI institute aims to address the increasing need, exacerbated by the COVID-19 pandemic, for the availability of speech and language services for children. The AI Institute will develop advanced AI technologies to scale speech-language pathologists' availability and services

such that no child in need of speech and language services is left behind.

- NSF will address a critical shortage of cybersecurity educators and researchers in priority areas including the cybersecurity aspects of AI as well as AI for cybersecurity, through the Education track in the SaTC program as well as the CyberCorps®: Scholarship for Service (SFS) program.
- As authorized by the CHIPS and Science Act, NSF will submit to Congress a report on the need and feasibility to implement an AI Scholarship-for-Service program to recruit and train the next generation of AI professionals to meet the needs of federal, state, local and tribal governments. The report will include an assessment of the capacity of institutions of higher education to produce graduates with degrees, certifications, and relevant skills related to AI.
- In FY 2024, GRFP will continue to encourage applications from students who are interested in pursuing AI-related research. The NSF GRFP recognizes and supports outstanding graduate students in NSF-supported STEM disciplines who are pursuing research-based master's and doctoral degrees at accredited U.S. institutions.
- The NRT program advances graduate education by combining interdisciplinary training with innovative professional development activities to educate the next generation of scientists and engineers capable of solving convergent research problems in areas of national need. In FY 2024, NRT will continue to include a special focus on traineeships in AI and other emerging industries that align with the Administration's priorities.
- In FY 2024, NSF's Computer Science for All (CSforAll) and Innovative Technology Experiences for Students and Teachers (ITEST) programs will continue to support projects that investigate promising educational approaches at the K-12 level to motivate and prepare a diverse cadre of learners for computationally intensive new industries, including those that that rely on AI.[5]
- In FY 2024, NSF will continue to support Data Science Corps in collaboration with philanthropic partners. This program enables education and workforce development by focusing on building capacity at the local, state, and national levels to unleash the power of data in service to society. Data Science Corps provides practical experiences, teaches new skills, and offers learning opportunities in a range of settings.

<u>Access to Data and Advanced Computing Research Infrastructure</u>

- In FY 2024, NSF will focus on the implementation of the recommendations in the NAIRR Task Force's final report, mentioned above, to amplify efforts across the federal government to cultivate AI innovation and advance trustworthy AI. The NAIRR is envisioned as a widely-accessible, national cyberinfrastructure that will advance and accelerate the U.S. AI R&D environment and fuel AI discovery and innovation in the United States. Specifically, NSF will work with other federal agencies and the broader community on the NAIRR Pilot Option outlined in the report to provide pilot-scale access to existing computational resources, software, datasets, services, and user portals across the current national cyberinfrastructure ecosystem.
- NSF supports a range of advanced computing systems and services for the full range of computational- and data-intensive research across all areas of science and engineering, including AI. For example, Frontera, the largest and most powerful supercomputer NSF has ever supported, will enable access to advanced computing resources for AI research. Furthermore, NSF will support innovative prototype systems such as Neocortex and Voyager. Specifically, Neocortex targets the acceleration of AI-powered scientific discovery, and Voyager targets research that involves extremely large data sets using standard AI tools.
- In FY 2019, NSF put in place a five-year cooperative agreement for $5.0 million with the University

[5] www.nsf.gov/pubs/2020/nsf20101/nsf20101.jsp

of California-San Diego, University of California-Berkeley, and University of Washington for the establishment and operation of CloudBank, an entity that helps the academic community access and use public clouds for research and education by delivering a set of managed services designed to simplify access to public clouds. CloudBank is specifically enabling new research in AI by broadening the access and impact of cloud computing across many fields of research and education. Furthermore, through the Dear Colleague Letter 22-087 announced in May 2022, the process has been further streamlined for easier access to cloud resources for active NSF awardees.

- For FY 2024, NSF will continue to collaborate with other federal agencies to enable researcher access to deep, high-quality, and accurate federal training datasets for AI systems. For example, NSF is building upon a FY 2021 workshop that explored how researchers might collaborate with federal data stewards to bring the latest security- and privacy-enhancing techniques to bear on unlocking access to federal data sets, while adhering to applicable federal statutes, rules, and regulations. For example, in FY 2023, NSF is continuing the Privacy-Enhancing Technologies (PETs) Prize Challenges in collaboration with OSTP, NIST, and the Government of the United Kingdom, to mature PETs toward the point of demonstrating their viability in the context of specific use cases,